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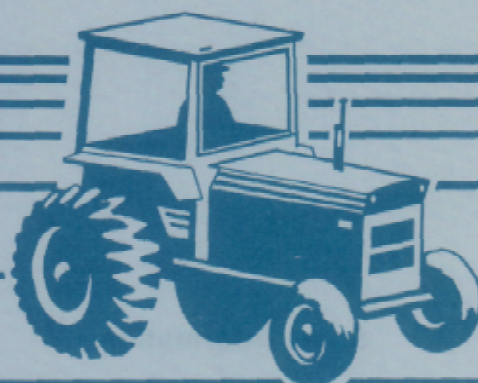
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# Trends in Double Cropping

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**Abstract**

U.S. farmers increased double-cropped acreage from 5.8 to 12.4 million acres during 1974-82, from 1.9 percent of all acres harvested in 1974 to nearly 4 percent in 1982. Double cropping was expanding because of rising commodity prices and producers' adoption of advanced technologies in plant varieties and farming practices. Appalachia, the Delta States, and the Southeast showed the sharpest growth in double cropping, partly because growing seasons there are relatively long. Double cropping declined after 1982 because of weak soybean prices, Government-sponsored idling of some wheat acreage that would otherwise have been double cropped, and unfavorable weather in several important double-cropping areas.

Keywords: Double cropping, conservation tillage, cropping systems, management.

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## Summary

Encouraged by favorable prices for their products and improved technology, U.S. farmers double cropped about 4 percent of all harvested acreage in 1982, nearly twice the 1974 percentage. This report examines the trends of double cropping (growing two crops per year in the same field) that characterized the 1970's and the reasons that double cropping declined after 1982.

Double-cropped land increased from 5.8 to 12.4 million acres during 1974-82. Double cropping expanded in all regions, especially Appalachia, the Delta States, and the Southeast which contained 44 percent of all double cropping in 1982. These regions have relatively long growing seasons and generally favorable precipitation patterns.

Soybeans double cropped with fall-seeded grains was the most prevalent form of double cropping. Double-cropped soybean acreage increased to a high of 11 million acres in 1982, nearly 16 percent of all soybean acreage planted. This acreage then steadily declined to 5 million acres in 1985, 8 percent of all soybean acreage.

Several factors made double cropping so attractive in the 1970's:

- Widened export markets that boosted prices.
- New early-maturing, high-yielding winter wheat and barley that permitted longer growing seasons for second crops.
- Advanced technologies and equipment that accelerated the use of conservation tillage which allowed for more timely planting.
- Improved herbicides that arrested weed growth when producers used conservation tillage.

Double cropping declined after 1982 because of weak soybean prices, Government-sponsored idling of some wheat acreage that would otherwise have been double cropped, and unfavorable weather in several important double-cropping areas.

Because double cropping offers more production options to growers, they can be more responsive to changes in market signals and growing conditions throughout the production year. But there is greater risk and expense compared with single-crop production. Continued development of shorter season varieties, pest and disease control practices, and improved management will allow farmers to expand double cropping to some areas where length of growing season and availability of soil moisture are currently limiting cropping possibilities.

# Trends in Double Cropping

Roger W. Hexem and Robert F. Boxley\*

## Introduction

Double cropping means that two crops are grown for harvest on the same field within a year. High prices and advanced technologies spurred the growth of double cropping in the 1970's. This report examines the trends during that decade and the downturn which occurred after 1982. This report draws on results from several studies of double cropping, mostly based on field experiments by agronomists. Factors affecting producers' adoption of double cropping and some impacts of using these cropping systems are examined. We take a close look at double cropping winter wheat and soybeans in three southern regions, and we estimate the effects of selected factors on producers' decisions to double crop.

## Background

Producers have double cropped for centuries, but the practice in the United States primarily began after the mid-1940's, becoming popular during the 1970's (7, 21).<sup>1</sup> Relatively long growing seasons and ample precipitation have long favored double cropping in southern and coastal States. Development of earlier maturing plant varieties, more supplemental irrigation, shifts from conventional to conservation tillage, and better farm management have encouraged farmers to double crop, particularly in other areas of the country. Multiple cropping, which usually includes vegetables, is possible in some areas. The term "double crop" will be used to represent both double and multiple cropping.

Growing conditions that affect the possibilities for double cropping vary widely across the United States. While farmers may anticipate higher net returns than with single cropping, they also face additional risks and expenses. Because double cropping permits a wider range of cropping

possibilities, growers may also be more responsive to changes in market and growing conditions throughout the production year.

## Types of Double Cropping

Most double cropping in the United States is sequential cropping and, to a lesser extent, relay intercropping. Sequential cropping means planting a crop within a year after a preceding crop has been harvested from the same field.<sup>2</sup> Winter wheat followed by soybeans is the most widely used cropping sequence. Relay intercropping means that two crops grow simultaneously during part of the life cycle of each. For example, farmers may plant corn or soybeans between rows of winter wheat before harvesting the wheat.

## Trends in Acreage Double Cropped

Few indicators of the extent of double cropping exist. National Agricultural Statistics Service (NASS), formerly the Statistical Reporting Service, develops unofficial estimates of the percentage of soybean acreage double cropped (32). Double cropping is not explicitly reported in the Census of Agriculture but can be estimated as the difference between total acres harvested and acres of harvested cropland because an acre double cropped is only counted as 1 acre of harvested cropland. Hay acreage harvested for different purposes within a year, for example, is counted as double cropped, so double-cropped land is overestimated in Census statistics.

The length of the growing season and the availability of soil moisture mostly determine the practicability of double cropping. Poor weather or lack of soil moisture may force farmers to harvest for forage rather than grain. Producers' decisions to double crop in any year depend on their expecta-

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<sup>1</sup>Italicized numbers in parentheses cite sources listed in the References section.

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<sup>2</sup>The production year is 12 months except in more arid areas where only one crop can be grown every 2 years because of insufficient soil moisture. In these areas, double cropping involves growing two or more crops every 2 years.

tions of the costs and returns for single-crop production compared with double-crop production.

Double-cropped acreage in the United States quadrupled during 1969-82, from about 3.1 to 12.4 million acres (table 1). Farmers' planting decisions were affected by Federal cropland diversion programs. Farmers withheld about 58 million acres from production in 1969 compared with 2 million acres, annually, during 1974-77. Diverted acreage increased to 18 million acres in 1978 but dropped to 11 million acres in 1982. During 1974-82, double-cropped acreage increased from 5.8 million acres to 12.4 million acres. Analyses of the Census data will focus on the 1974-82 period because this period was relatively free of the effects of the cropland diversion programs of 1969.

**Table 1—Acres double cropped and percentage of U.S. total, by region<sup>1</sup>**

Region	1969	1974	1978	1982
<i>1,000 acres</i>				
Double-cropped acres:				
Northeast	158	409	575	694
Lake States	275	678	1,093	1,078
Corn Belt	816	1,511	1,611	2,130
Northern Plains	422	721	1,387	1,536
Appalachia	308	830	712	1,811
Southeast	308	407	567	1,529
Delta States	275	367	404	2,113
Southern Plains	240	343	492	603
Mountain	115	189	390	360
Pacific	190	306	508	499
United States <sup>2</sup>	3,107	5,761	7,739	12,353
<i>Percent</i>				
Share of U.S. total:				
Northeast	5.1	7.1	7.4	5.6
Lake States	8.8	11.8	14.1	8.7
Corn Belt	26.3	26.2	20.8	17.3
Northern Plains	13.6	12.5	17.9	12.4
Appalachia	9.9	14.4	9.2	14.7
Southeast	9.9	7.1	7.3	12.4
Delta States	8.9	6.4	5.2	17.1
Southern Plains	7.7	5.9	6.4	4.9
Mountain	3.7	3.3	5.1	2.9
Pacific	6.1	5.3	6.6	4.0
United States <sup>2</sup>	100.0	100.0	100.0	100.0

<sup>1</sup>Because of changes in the definition of a farm, 1969 data are not strictly comparable with data for later years. Acres double cropped represent the difference between total acres harvested and acres of harvested cropland when an acre double cropped is only counted as 1 acre of harvested cropland.

<sup>2</sup>Excludes Alaska and Hawaii.

We associated increases in double cropping with several factors:

- Expanding export markets in the 1970's and sharply higher prices which increased the profitability of double cropping.
- Producer adoption of early-maturing, high-yielding winter wheat and barley which permitted a potentially longer growing season for second crops such as soybeans, corn, and sorghum.
- New technology and equipment that accelerated farmers' adoption of conservation tillage, particularly no-till, allowing more timely planting of the second crop.
- New herbicides that provided good weed control when conservation tillage was used.

While acreage increased in all regions during 1974-82, acreage more than doubled in the Appalachian region to 1.8 million, nearly quadrupled in the Southeast to 1.5 million, and was almost six times higher in the Delta States where acreage increased from nearly 400,000 to 2.1 million acres. Expansion was also significant in the Corn Belt and Northern Plains where 2.1 million and 1.5 million acres, respectively, were double cropped in 1982. Double cropping is least prevalent in the Mountain and Pacific regions, where either lack of moisture or length of growing season limits cropping possibilities.

Regional shares of U.S. double-cropped acreage shifted from northern to southern regions during 1974-82 (table 1). The Lake States and Corn Belt had a combined 38 percent of all acreage double cropped in 1974 but only 26 percent in 1982. During the same years, double-cropped acreage in the Southeast and Delta States jumped from 13.5 percent to 29.5 percent.

While farmers are double cropping more acres, the total acreage is relatively small. In 1982, farmers double cropped only 3.7 percent of all acres harvested in the United States compared with 2.4 and 1.9 percent in 1978 and 1974, respectively (table 2). The highest regional incidence of double cropping in 1982 occurred in Appalachia, the Delta States, and the Southeast where 9 to 10 percent of harvested acres was double cropped in each region (fig. 1). Farmers double cropped 5 percent of the acres in the Northeast and less than 3 percent of all acres in the balance of the regions.

Source: (35).



Favorable prices for small grains and soybeans during the 1970's encouraged growers to increase the percentage of double-cropped soybean acreage from about 5 percent in 1978 to a high of nearly 16 percent in 1982.

**Table 2—Acres double cropped as percentages of total acres harvested, by region<sup>1</sup>**

Region	1969	1974	1978	1982
	<i>Percent</i>			
Northeast	1.4	3.3	4.3	5.1
Lake States	.9	2.0	3.0	2.8
Corn Belt	1.2	1.9	2.0	2.5
Northern Plains	.7	1.0	2.0	2.1
Appalachia	2.3	5.4	4.1	9.4
Southeast	2.8	3.4	4.1	10.4
Delta States	1.8	2.4	2.2	10.5
Southern Plains	.8	1.2	1.7	2.0
Mountain	.5	.8	1.5	1.5
Pacific	1.3	1.8	2.9	2.8
United States <sup>2</sup>	1.1	1.9	2.4	3.7

<sup>1</sup>Because of changes in the definition of a farm, 1969 data are not strictly comparable with data for later years.

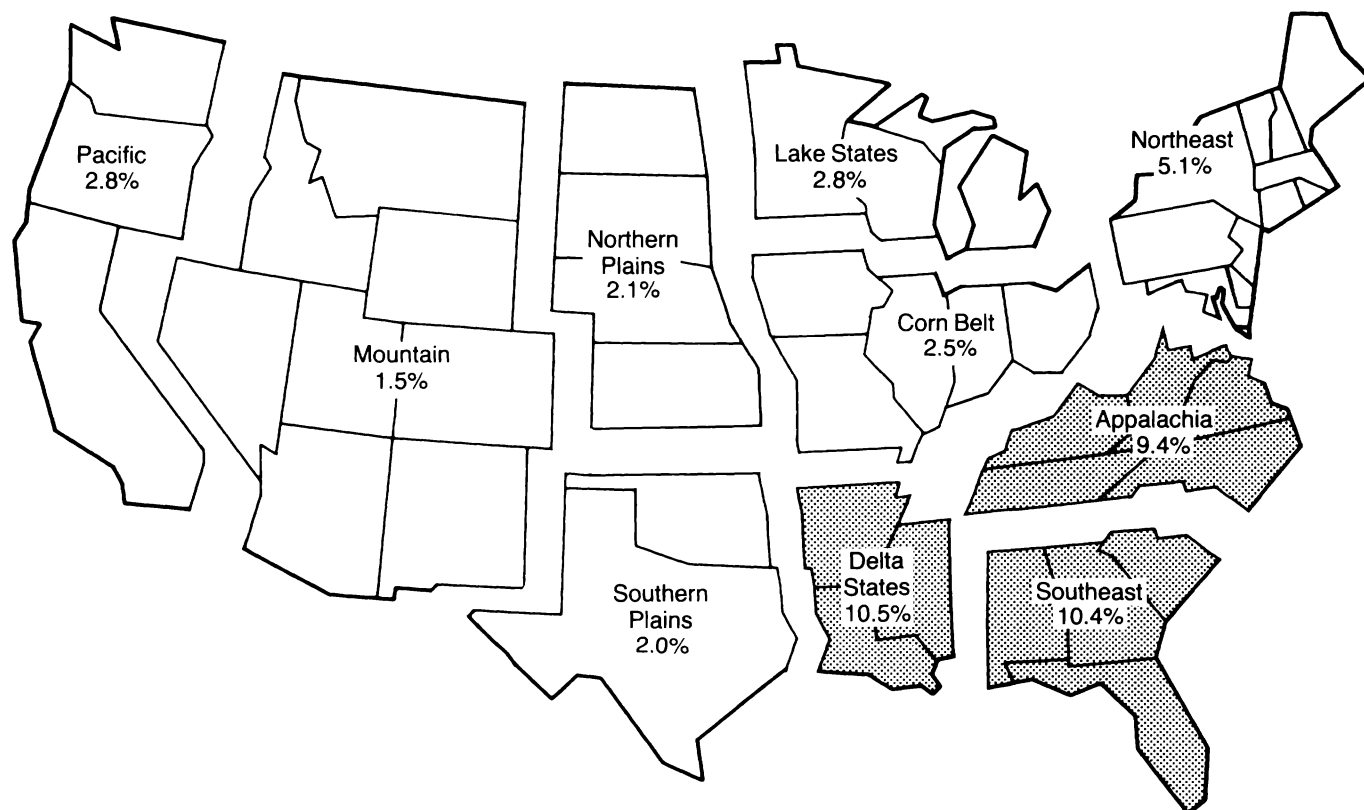
<sup>2</sup>Excludes Alaska and Hawaii.

Source: (35).

cent in 1982. Thereafter, the percentage steadily declined, arriving at 8 percent in 1985 (table 3). (NASS first published these unofficial estimates in 1978.) The 1982-83 percentage reductions in most regions likely followed declines in soybean prices which began in mid-1982 and prompted an 11-percent reduction in soybean acres planted (32). Idling wheat and other small grain acreage with the payment-in-kind (PIK) program and other cropland diversion programs in 1983 also reduced the plantings of soybeans which would have been double cropped with small grains. Despite higher soybean prices beginning in mid-1983 and an 8-percent increase in acres planted during 1983-84, double-cropped soybean acreage dropped to 7.4 million acres in 1984, about 11 percent of all soybeans planted. The 1983-84 decline partly resulted from unfavorable weather in portions of the South which delayed harvesting of small grains and planting of soybeans as a second crop. A combination of factors including lower prices for wheat and soybeans (although the support price for wheat was up slightly), an increase in acreage of cropland diverted, and unfavorable weather delaying plant-

Figure 1

**Double-cropped acreages as percentages of total acres harvested in 1982 were highest in Appalachia, the Southeast, and the Delta States**



ings of both fall-seeded grains and soybeans in portions of several regions caused growers to reduce acreages of fall-seeded grains in 1984 and soybeans in 1985 from 9 percent to 7 percent below respective levels a year earlier.

Farmers double cropped soybeans on a high percentage of acres in the Northeast (Delaware, Maryland, New Jersey, and Pennsylvania), but this region accounted for only 1 million acres of soybeans in 1985, less than 2 percent of the U.S. total. Percentages were also high in Appalachia and the Southeast where farmers planted 15 percent of all soybeans in 1985, nearly 45 percent of them double cropped.

Although the Corn Belt accounted for nearly half of U.S. soybean acreage planted in 1985, the region had only 18 percent of all soybean acreage double cropped. Delta States double-cropped soybean acres

have steadily declined from a high of 3 million acres in 1982 to 700,000 acres in 1985. During this period, acreage of fall-seeded grains dropped by two-thirds, and soybean acreage was off 20 percent. Unfavorable weather in 1984 and 1985 was especially damaging in the Delta States.

Acres planted to double-cropped soybeans in the Plains regions have not varied much in recent years. Farmers do not double crop soybeans in the Lake States because the growing season is too short. Few soybeans are grown in the Mountain and Pacific regions.

## Some Impacts of Shifting to Double Cropping

Shifts from single to double cropping increase the productive capacity of the agricultural sector. Dou-

**Table 3—Percentages and acres of soybeans double cropped, by region, 1978-85<sup>1</sup>**

Region	1978	1979	1980	1981	1982	1983	1984	1985
<i>Percent</i>								
Percentage of acreage double cropped:								
Northeast	22.5	21.2	26.2	36.8	38.5	33.3	28.8	36.0
Lake States								
Corn Belt	3.0	3.0	3.7	6.0	4.9	5.1	4.8	2.8
Northern Plains <sup>2</sup>	3.6	3.8	8.5	7.8	4.1	3.4	5.1	3.9
Appalachia	8.3	11.4	23.7	36.2	34.9	33.0	31.7	27.4
Southeast	17.9	16.9	22.8	37.2	47.6	31.7	29.8	34.5
Delta States	4.2	6.0	9.3	18.4	26.6	21.3	18.1	7.6
Southern Plains	9.8	11.6	12.7	24.3	25.8	11.5	15.7	8.9
Mountain								
Pacific								
United States <sup>3</sup>	5.2	5.8	8.9	14.3	15.7	12.3	10.9	8.1
<i>Million acres</i>								
Acreage double cropped:								
Northeast	0.2	0.2	0.3	0.3	0.4	0.3	0.3	0.3
Lake States								
Corn Belt	.9	1.0	1.2	1.8	1.6	1.5	1.5	.9
Northern Plains <sup>2</sup>	.1	.2	.4	.4	.2	.3	.3	.2
Appalachia	.5	.8	1.6	2.4	2.4	1.9	1.9	1.4
Southeast	1.0	1.1	1.5	2.4	3.2	1.7	1.6	1.6
Delta States	.5	.8	1.1	2.1	3.0	2.1	1.7	.7
Southern Plains	.1	.1	.1	.2	.3	.1	.1	.1
Mountain								
Pacific								
United States <sup>3,4</sup>	3.4	4.1	6.2	9.7	11.1	7.7	7.4	5.1

<sup>1</sup>Percentages are designated as unofficial estimates by USDA's NASS. <sup>2</sup>Estimates reported for Kansas only.

<sup>3</sup>Excludes Alaska and Hawaii. <sup>4</sup>Due to rounding, numbers may not sum to totals.

Source: (32).



ble cropping wheat and soybeans, for example, has increased per acre productivity by 30 percent in regions generally south of 40° north latitude which bounds southern portions of the Northeast and Corn Belt regions (12). But, estimates of changes in productivity depend on the cropping systems being compared. Per acre volume of output with wheat/soybeans in Georgia has about doubled that of full-season soybeans and has been somewhat comparable to full-season corn (16, 40). With irrigation, the per acre volume of wheat/soybeans was 75 percent higher than full-season soybeans but 40 percent less than full-season corn. Double cropping corn and soybeans or sorghum could help alleviate feed grain deficits in some areas, such as the Southeast (39). Increased capacity is especially important during times of growing domestic and export demand, but during periods of overproduction, could complicate Federal programs designed to control acreage and production.

Double cropping provides several production options to farmers. Those who can choose from several cropping possibilities throughout the production year can be more responsive to changes in market prices and have greater flexibility to alter crop patterns as growing conditions change. Small grains, as a typical first crop, can be harvested for grain, silage, or hay; can be grazed; or can simply be used as a cover crop. The second and, in some cases, third crop could be soybeans, sorghum, corn grown for grain or forage, or vegetables.

Soils may be more exposed to wind and water erosion when farmers double crop. Fields are most susceptible to erosion from time of preparation to about 60 days after planting. When double cropping, two periods of potentially high erosion exist each year (11). But, because double cropping usually provides more ground cover, some analysts assert that erosion hazards may be reduced (6, 17).

Shifts from conventional to conservation tillage facilitated farmers' adoption of double cropping. Conservation tillage, however, requires heavy applications of herbicides and other agricultural chemicals. Some chemicals adhere to soil particles or solubilize in soil runoff and water percolation, increasing the possibilities of contaminating the water.

When producers' net returns increase and/or stabilize through double cropping, the economic viability of their operations should improve. Returns from the first crop can be used for production expenses for other crops, improving farmers'

cashflow positions throughout the production year. Because farmers use more inputs for double cropping than single cropping, agribusiness should benefit.

## **Factors Affecting Adoption of Double Cropping**

The decision to double crop can vary from year to year, particularly in areas where growing conditions limit cropping possibilities. Double cropping is economically feasible when weather favors early planting and harvesting of the first crop, soil moisture is adequate for establishing a second crop, and expected cost/price relationships are favorable to the farmer. Double cropping, which is more risky and costly than single-crop farming, depends on certain crucial factors besides good weather for success, including the producer's managerial abilities and the state of national and world economies.

### **Growing Conditions**

The length of the growing season and the amount and distribution of precipitation principally determine the feasibility of double cropping. The average length of a frost-free period varies widely across the United States. If the growing season is relatively long, for example, 250 days or more, two summer crops involving some combination of corn, soybeans, sorghum, and sunflowers may be successful (4, 39, 40, 42). But, supplemental irrigation plus close and judicious management are required for sustained success. Gomm and others state that 200 or more frost-free days plus adequate irrigation water are required for successful double cropping (using "present agronomic crops and varieties") in the Western United States, while nonirrigated production requires at least 30 inches of annual precipitation (9).

Double cropping grains with soybeans is possible up into southern portions of the Corn Belt where the frost-free period averages 170-180 days. As the growing season becomes shorter in central and northern regions, cropping possibilities are fewer, and more crops in double-cropping systems are grown for forage rather than grain (3, 17).

Adequate soil moisture is particularly critical for quick germination and establishment of the second crop (15,17,21,25), especially for Class III and higher soils which tend to have lower moisture-holding capacities than Class I and II

soils (6).<sup>3</sup> If soil moisture is inadequate, farmers must either delay planting until rainfall or apply supplemental irrigation. Delayed establishment of the second crop may lower yields, making double cropping less profitable or unprofitable (3, 15, 28, 30). However, if growers plant the second crop on time and if soil moisture and nutrients have not been unduly depleted in producing the preceding crop, second-crop yields should be comparable to single-season yields (15, 18, 21, 40).

Conservation tillage helps retain soil moisture. If farmers use no-till methods, the crop can be planted immediately after harvesting the first crop, increasing the growing season for the second crop. Soil temperatures may decline because of crop residues, however, retarding seed germination in cool regions. Insects and plant diseases may pose severe problems when farmers use conservation tillage (24, 30). But, these are problems in some southern areas even with conventional tillage (4, 40, 42).

## Management Requirements

Double cropping requires a high level of management. Producers often confront late planting, a short growing season, low soil moisture, depleted soil nutrients, increased pests and diseases, and drought stress when growing the second crop. Successful management of double-cropping systems involves timely decisions on planting and harvesting dates; careful selection of early-maturing varieties, cropping systems, row spacing, plant population, and herbicides; and possible use of conservation tillage for summer row crops (15, 40).

In years of adverse weather and/or in areas with limited growing seasons, fall-seeded grain—a typical first crop—may need to be harvested while at a high-moisture content and then artificially dried or used as silage. Otherwise, second-crop planting may be delayed. If harvest of the second crop, such as soybeans, is delayed, yields of the fall-seeded grain crop following soybeans may decline (2, 28). When soil moisture is low, one of the crops may be excluded.

No-till cultivation eliminates the time and expense of field preparation for the second crop, but weed control may be a problem. Proper selection and

timely applications of preemergence and post-emergence herbicides are required for weed control and elimination of crop-damaging residual herbicides. Residue and mulch from conservation tillage can intercept herbicides being applied, thereby reducing their effectiveness (1, 20, 25, 40). Use of no-till does not seem to reduce yields when weed, insect, and disease problems are minor or can be controlled (8, 15, 29, 37). Other factors, such as planting date and soil moisture conditions, are more likely to limit yields. In dry years, no-till land may produce higher yields (11, 21, 37). Poor seed-soil contact can also be a major problem (10, 30). Seeding rates and plant population may need to be increased.

Nutrient management is important because, for example, if the second crop is on no-till land, nutrients for both crops will usually be applied when the first crop is fertilized (25, 40). Harvesting the entire plant may remove at least twice as many nutrients as harvesting only the grain (41). If, for example, a fall-seeded grain is grazed or harvested as silage, nutrient needs for the second crop will require close attention.

## Economic Conditions

Producers anticipate increased returns when they double crop. Although additional risks and expenses are involved, price and production uncertainties are spread over two or more crops, which may stabilize returns and improve producers' creditworthiness.

Even though second-crop yields may be lower than for a single crop, returns can be comparable or higher because of reduced production costs, especially if no-till cultivation is used. Spreading fixed costs of production over two or more crops reduces unit production costs for individual crops, and residual plant nutrients can be used for producing the second crop.

The relatively few studies of the economics of double cropping are based on field experiments conducted by agronomists. Because cropping systems, cultivation practices, growing conditions, and cost-price relationships vary among these experiments, we can make few generalizations. Much less is known about profitability under actual field conditions and in combination with other crop and livestock enterprises within farm units.

Based on trials involving spring-sown oats, corn, and soybeans in south-central Iowa in the late

<sup>3</sup> Land capability classes I through VIII indicate the degree of physical limitation to cultivation. Land in classes I-III is suitable for continuous cultivation. Land in class IV is less suitable for cultivation. Land in classes V-VIII is generally considered unsuitable for crops requiring cultivation. For a description of the SCS land capability classifications, see (13).

1970's, researchers found that returns on the most profitable combination of oats and corn were only about half the returns to single-crop corn (17). When corn was grown as a second crop, yields were only 60 percent or less of single-crop corn. Returns on some combinations of oats silage and soybeans were higher than those on single-crop soybeans. Yields of second-crop soybeans varied with row width, plant population, and weather conditions and ranged from 65 to 110 percent of single-crop yields.

Returns to land and management on winter wheat/soybeans in southern and south-central Indiana in 1979 were an estimated 5 and 15 percent higher, respectively, than returns on single-cropped soybeans and corn (19). In developing their simulated cost and return budgets, researchers assumed that producers were using improved managerial practices on better quality land and that second-crop soybean yields were 60 percent of single-crop yields. When farmers harvested wheat early and dried it, they were able to plant soybeans earlier; estimated returns increased 23 and 34 percent, respectively, above single-cropped soybeans and corn.

Average returns to land and management with conventionally planted wheat followed by no-till soybeans in the Piedmont and Coastal Plains of North Carolina during 1971-74 were only slightly higher than single-cropped corn grown with no-till cultivation (15). Returns on single-crop corn were substantially higher than returns on double-cropped wheat and no-till corn and returns on wheat and no-till grain sorghum. Tillage practices affected yields and, in turn, net returns on other cropping systems.

Single-crop soybean yields averaged 6 to 8 bushels higher than second-crop soybeans in northeastern Louisiana in the late 1970's (2). These reduced yields increased concern about farmers making a profit with double cropping. Supplemental irrigation, usually needed for second-crop soybeans, produced returns sufficient to cover production costs.

Cotton yields following winter wheat were 45 to 65 percent of single-crop cotton yields in east-central Arkansas during 1976-79 (21). Several factors discouraged growers from double cropping cotton and wheat in northern zones of the cotton production area: lower cotton yields, reduced wheat yields when fall plantings of wheat were late, and the need to dry and store high-moisture wheat in some years.

Alternative tillage and wheat straw management systems raised returns on wheat/soybeans in Mississippi during 1974-76 (20). Average net returns on four of the five double-cropping systems studied exceeded returns on single-crop soybeans by from 10 to 84 percent. Returns on the fifth system were 15 percent below single-cropped soybeans.

Wheat/soybean production on clay soils in Mississippi was studied during 1981-83 (38). Returns over variable costs and fixed costs for machinery averaged about \$115 per acre for wheat/soybeans using conventional tillage and irrigation, only \$5.10 above conventionally tilled single-crop soybeans. Net returns from double-cropped plots on which researchers used minimum tillage and no-till were 65 and 43 percent, respectively, of returns on single-crop soybeans grown with conventional tillage. Soybean yields were considerably lower without irrigation, and returns on single-crop soybeans with conventional tillage and on soybeans as a second crop grown with minimum tillage and no-till all were negative. Only conventionally tilled wheat/soybeans had returns higher than those for single-crop wheat, but the difference averaged only \$6.20 per acre. Double cropping with conservation tillage was less profitable than producing single-crop wheat.

Net returns to land, management, and general farm overhead for wheat/soybean double cropping averaged about one-third above returns to single-crop soybeans in southwestern Georgia during 1975-79 and four times higher than returns to single-crop corn (16). Researchers raised all crops without irrigation. Returns were highly variable, however, ranging from \$4 to \$255 per acre for wheat/soybeans. Variation in returns primarily resulted from fluctuations in yield.

Double cropping fall-seeded grains or spring-planted crops with soybeans is feasible throughout Georgia (40). Two summer crops, such as early summer crops of corn, grain sorghum, or sunflowers followed by soybeans, can be profitable on some fertile, irrigated fields in south Georgia where the frost-free period is 250 or more days (40, 41). However, more intensive management is required.

Per acre returns to land, management, and general overhead with conventionally tilled wheat/soybeans grown without irrigation were \$60 in 1980-81, but dropped to \$24 in 1984-85 (5, 40). Production costs were up; prices received were down. Returns to irrigated wheat/soybeans in 1984-85 were an

estimated \$61 per acre, and returns to winter grazing of fall-seeded ryegrass followed by nonirrigated soybeans dropped from \$92 per acre in 1980-81 to \$23 in 1984-85.

Returns to risk and management for corn, grain sorghum, and soybeans as second crops in double-cropping systems were nearly always negative based on several experiments involving combinations of field crops and vegetables grown on two soil types with irrigation in south-central Georgia during 1978-82 (22, 23, 26, 27). The exceptions were some experiments with corn silage and grain sorghum in 1978 (26). Cropping systems including vegetables were generally more profitable.

Several of these experiments occurred during the 1970's. Cost-price relationships for principal crops in double-cropping systems have become more unfavorable since the mid-1970's. The index of prices paid has steadily increased while producer prices have varied with no established trend. However, support prices for wheat, corn, and sorghum have been increasing for several years.

## Estimating Factors Associated with Double-cropped Soybean Acreage

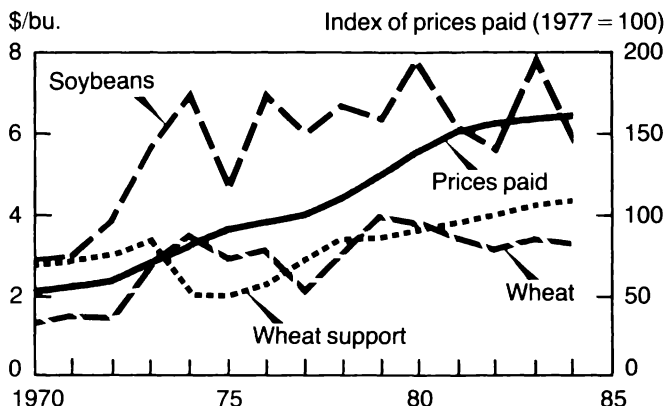
Relationships among successful double-cropping techniques can be analyzed in farm management studies. But, detailed information on farmers' financial positions, managerial capabilities, crop/livestock enterprises, economic planning horizons, and other factors are required. We used secondary data to partially examine factors affecting farmers' decisions to double crop soybeans with fall-seeded wheat in Appalachia, the Southeast, and the Delta States. Multiple regression analyses were used in a two-phase approach. We analyzed changes in acreages of winter wheat and then used reported acreages of winter wheat planted as an explanatory variable to analyze factors associated with variation in acreage of double-cropped soybeans.

Producer prices, averaged across the regions, depicted price movements. Soybean prices fluctuated during 1974-84 but without trend (fig. 2). Soybean yields also varied without trend (34). Yet, soybean acreage trended upward during 1974-82 in Appalachia and the Southeast, then declined (figs. 3 and 4). Acreage began declining in the Delta States in 1980 as growers shifted some cropland from soybeans to sorghum and cotton (fig. 5).

Wheat prices also varied without trend during 1974-84, but the support price increased rather steadily from \$2.05 in 1974 to \$4.38 in 1984. Wheat yields trended upward slightly during the late 1970's and early 1980's. The amount of acreage planted was largely unchanged for several years in all three regions until producers began planting more acres in late 1970. Double-cropped soybean acres also increased at that time. Because (a) production costs were increasing, (b) producer prices for soybeans and wheat were fluctuating without trend (although wheat support prices were increasing), (c) soybean yields were varying without trend, and (d) wheat yields were increasing slightly, expansions in soybean and winter wheat acreage

Figure 2

**Producer prices increase through 1974 in response to expanding export demand but then vary without trend during 1974-84\***

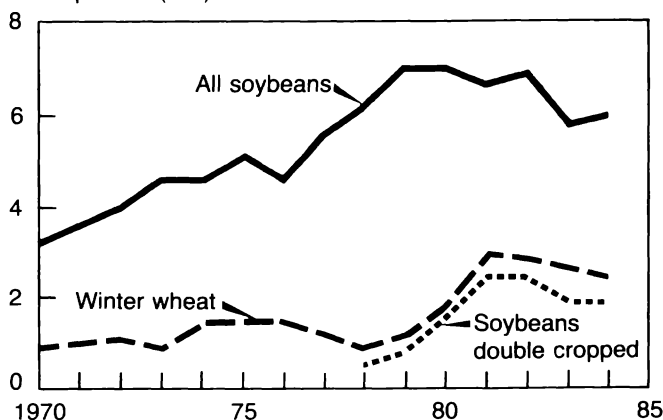


\*Average producer prices for wheat and soybeans in Appalachia, the Southeast, and the Delta States.

Figure 3

**Appalachian double-cropped soybean acreage peaks in early 1980's, then tapers off**

Acres planted (mil.)



Source: (34).

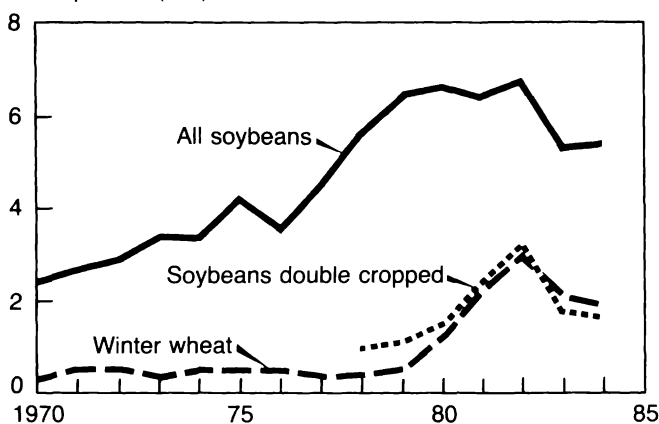
were seemingly related to changes in technology and producers' adoption of improved management and new cropping systems.

Changes in double-cropped soybean acreage closely paralleled those for winter wheat. Although soybeans may not have been more profitable as a single crop, they apparently were when double cropped. Neither corn nor cotton, the two major crops competing with soybeans, established trends in either prices or yields that would suggest they were more profitable than soybeans. This helps explain the strong expansion in soybean acreage during the 1970's and early 1980's.

Figure 4

#### **Southeast double-cropped soybean acreage peaks in early 1980's, then tapers off**

Acres planted (mil.)

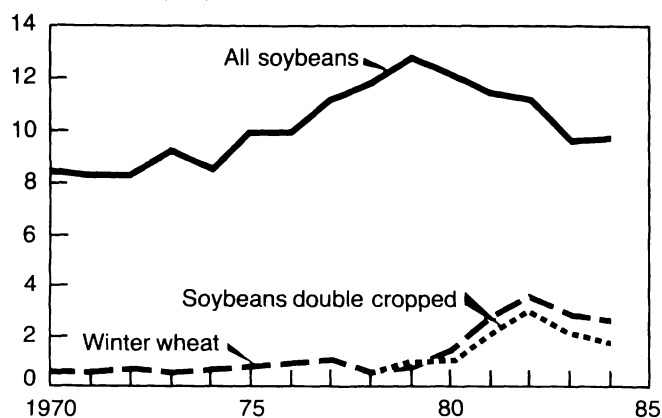


Source: (34).

Figure 5

#### **Delta States double-cropped soybeans peak in 1982, then decline**

Acres planted (mil.)



Source: (34).

## **Winter Wheat Acreage**

Farmers' decisions to plant winter wheat are conditioned by their expectations of the profitability of growing wheat compared with other crops and by Federal price support and acreage-control programs for wheat. The principal crops competing with double-cropped wheat/soybeans are corn in Appalachia and the Southeast and cotton in the Delta States. We used producer prices as proxies for changes in profitability of growing wheat and other crops. We excluded soybean and sorghum prices in the analyses because each was highly correlated with corn and cotton prices. Several price variables, such as annual and 2-year average producer prices, Federal support prices, and the higher of support prices or producer prices, were considered for wheat, corn, and cotton. Because corn and cotton prices were highly correlated with wheat prices, we set prices as ratios in the models.

Growing conditions also affected farmers' decisions to plant winter wheat. If the preceding crop was harvested relatively late and/or soils were too wet or too dry, fewer acres of fall-seeded grains were likely planted. We used wheat yields as a proxy for growing conditions at planting time. This variable was later discarded because yields were highly correlated with other variables.

Because wheat acreage diverted from production under Federal programs directly affected acreage planted, a variable representing diverted wheat acreage was included. Several dummy variables representing possible changes in technology, management, and cropping systems in the late 1970's and early 1980's were considered in our analyses.

These variables accounted for 92 to 96 percent of the variation in winter wheat acreage during 1970-84 (app. table 1). All estimated coefficients had the expected signs: acreage of winter wheat was positively related to changes in both the price variable and the time dummy variable and was inversely related to changes in wheat acreage set aside through Federal farm programs. Based on values of the Durbin-Watson statistic, serial dependence among the error terms was not evident (14).

All coefficients in the Appalachian model were highly significant. Growers' decisions to plant correlated strongly with the wheat/corn price ratio in the preceding year. Levels of support prices were not important. If the wheat/corn price ratio increased

by 0.1 point and other variables were unchanged, winter wheat acreage was expected to increase by about 114,800 acres. With unweighted mean prices of 4.5 cents/lb for wheat and 4.2 cents/lb for corn during 1970-84, the price ratio equaled 1.07. A 0.1-unit increase to 1.17 would have occurred if the wheat price increased 24 cents/bu (0.4 cent/lb) with the corn price unchanged, if the corn price decreased 20 cents/bu (0.35 cent/lb) with the wheat price unchanged, or some combination of price changes. Each acre of wheat base acreage diverted from production corresponded to only a 0.61-acre reduction in winter wheat planted. This lack of one-to-one correspondence resulted because some who did not participate in the wheat diversion programs increased their acreage which, in turn, partially offset the acreage cutbacks by others participating in the programs. The coefficient for the dummy variable, T, was also highly significant. Farmers substantially increased planted acreages in the early 1980's after adopting improved technology and management, different cropping systems, and/or because of some other factors not specified in the model but correlated with time.

According to the Southeast model, growers were somewhat less responsive to changes in the wheat/corn price ratio than in the Appalachian region. This was probably because farmers in the Southeast had more cropping possibilities, and the wheat/corn price relationship was somewhat less important. The coefficient for diverted acreage was not significant at conventional levels (although significant at the 15-percent level) partly because levels of acreage diverted were significantly correlated with T, and effects of the two variables could not be separated.

We found that values of diverted acreage and T were also correlated in the Delta States model. The coefficient for the wheat/cotton price ratio was not statistically significant at conventional levels. Other price relationships apparently were more important during this period. The relatively large value for the price coefficient partly resulted from the wide differences in unit prices of wheat and cotton and the low values of the ratios. The average price for wheat during 1970-84 was \$2.85 (4.8 cents/lb) and 51 cents/lb for cotton, producing a price ratio of only 0.094.

### **Double-cropped Soybean Acreage**

Because changes in acres of double-cropped soybeans closely paralleled planted acres of winter wheat in all three regions, wheat acreage was a

principal variable in explaining variation in double-cropped soybean acreage. Soybeans and sorghum were the most widely planted second crops in double-cropping systems. Because prices for these crops were highly correlated, we used price ratios in the regional models. Two additional variables were included in preliminary analyses but were later omitted. Soybean yields served as a proxy for growing conditions around soybean planting time. Dummy variables representing possible changes in technology, management, and cropping systems were also evaluated.

The winter wheat acreage and soybean/sorghum price ratio variables explained 94 to 98 percent of the variation in acreage of double-cropped soybeans during 1970-84 in the three regions (app. table 2). Based on values of the Durbin-Watson statistic, serial correlation among the error terms was not evident in Appalachia. The values were inconclusive for the other two regional models (14).

Each acre of winter wheat planted in the Appalachian region corresponded with 0.97 acre of double-cropped soybeans. With longer growing seasons and more cropping possibilities in the Southeast and Delta States, the relationship between winter wheat acreage and double-cropped soybeans fell to 0.81 and 0.76, respectively. Coefficients were highly significant in all regions.

Producers seemed to have been highly responsive to changing price relationships when making decisions to double crop soybeans. In Appalachia, for example, a 0.1-unit increase in the soybean/sorghum price ratio was associated with about a 26,500-acre increase in double-cropped soybeans. Unweighted mean prices for soybeans and sorghum during 1970-84 were 8.7 cents/lb and 3.7 cents/lb, respectively, with a price ratio of 2.35. A 0.1-unit increase in the ratio to 2.45 could have occurred if the soybean price had increased by about 0.36 cent/lb (22 cents/bu) with the sorghum price unchanged, or if the sorghum price had declined by 0.15 cent/lb (15 cents/cwt) with the soybean price unchanged, or some combination of price changes. We similarly interpreted coefficients for price variables in other regions. Because more types of double-cropping systems were feasible in the Southeast and Delta States than in Appalachia, we expected coefficients for the soybean/sorghum price variable in these two regions to be lower than the price coefficient for Appalachia. The coefficient in the Southeast model, however, was substantially higher.

## Wrap-up on Double Cropping

Double-cropped acreage increased substantially in the 1970's and early 1980's with fall-seeded grains followed by soybeans as the most prevalent cropping sequence. Farmers then planted fewer acres of double-cropped soybeans in response to lower producer prices, unfavorable weather in some areas, and more wheat acreage placed in Federal wheat set-aside programs, some of which would have been double cropped with soybeans.

Lower prices for farm products are expected in 1985/86 as increasing production and shrinking export markets expand domestic reserves of principal crops and reduce market prices. Federal support prices had climbed for several years until 1985 when they were set at 1984 levels.

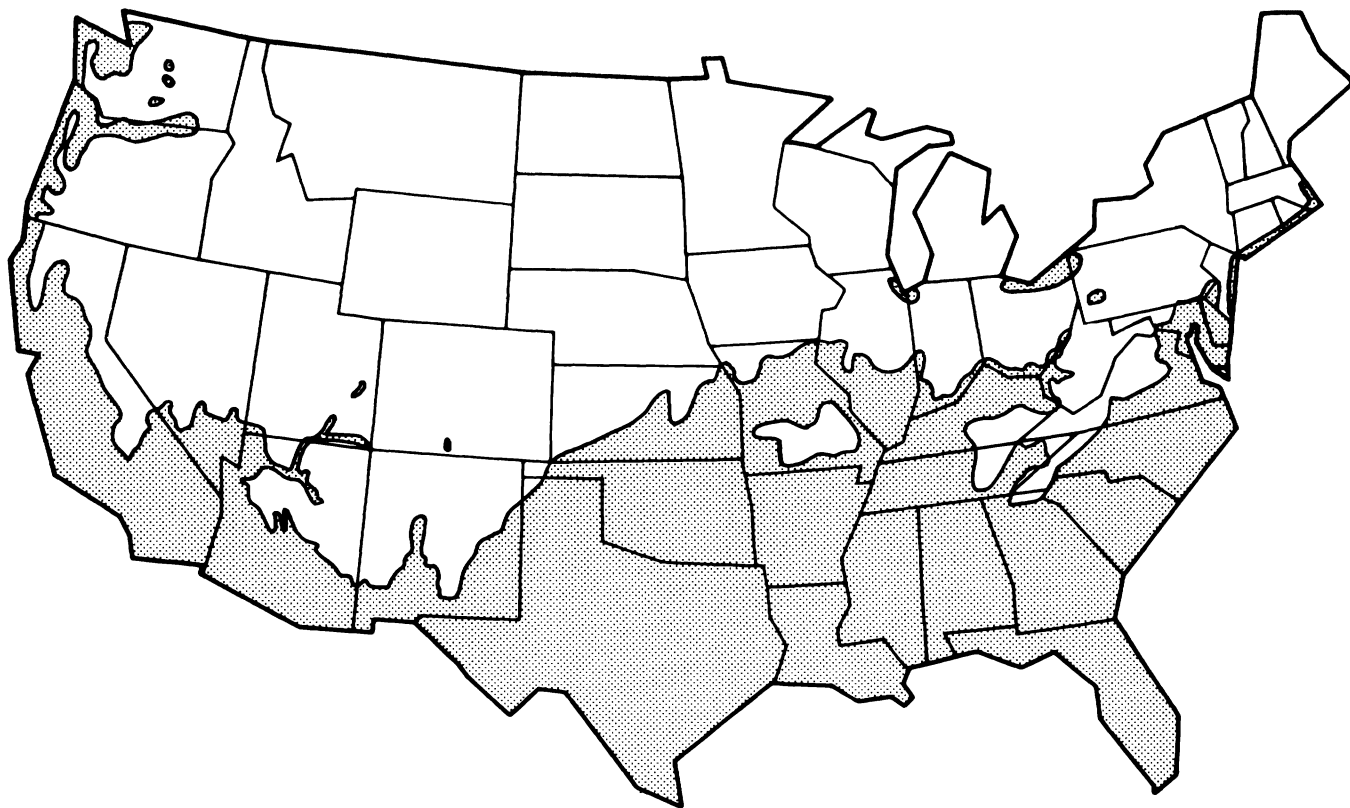
Provisions in the Food Security Act of 1985 will affect farmers' cropping decisions, including those to double crop. Farm policies will be more closely geared to market conditions than in prior years. Target prices for major commodities will decline

during 1986-90. Loan rates will be tied to an average of past market prices, and the Secretary of Agriculture has more discretion to adjust loan rates than in earlier years. The legislation requires that specific acreage limitation programs for wheat and feed grains be implemented if stocks are expected to exceed certain levels. Program requirements for cotton and rice are less stringent. Farmers will be encouraged to place at least 40 million acres of highly erodible cropland in a conservation acreage reserve by 1990.

Weather conditions will continue to affect farmers' decisions to double crop in any particular year. The length of the growing season and available soil moisture may vary, but no long-term changes are anticipated. Small grains and row crops are double cropped in southern portions of the Corn Belt where the frost-free period is 170-180 days and in other regions with longer growing seasons. Figure 6 shows areas with frost-free periods of 180 days and longer. Most of the lower half of the Eastern United States plus coastal areas up to New York and a small area just below Lake Erie have suffi-

Figure 6

### Longer growing season encourages double cropping\*



\*Shaded areas have average frost-free periods of 180 days or longer.

Source: (36)



ciently long growing seasons for double cropping. Areas that could support double cropping in the Western United States include eastern and southern Kansas, Texas and Oklahoma, much of Arizona and New Mexico, the crop production regions in California, and coastal areas of Oregon and Washington. But, recall that farmers are employing some forms of double cropping nationwide and in regions with much shorter growing periods.

Factors that limit expansion of double cropping will be less confining in the future because of the development of shorter-season plant varieties. Double cropping will likely increase because of other factors, such as more disease- and insect-resistant plant varieties, shifts from conventional to conservation tillage which permit more timely planting of the second crop, research on chemicals more suitable to weed and pest control in sequential cropping, adoption of improved management of double-crop systems, and more supplemental irrigation.

Opportunities for increasing the double-cropped acreage exist in several parts of the country. More opportunities will unfold, but possibilities for economic returns below those of single cropping will also develop. Producers will need to make adept managerial decisions.

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**Appendix table 1—Estimated associations between acres of winter wheat planted (1,000 acres) and specified variables, 1970-84**

Region	Intercept	(W/C) <sub>p</sub> <sup>3</sup>	(W/Ctn) <sub>p</sub> <sup>4</sup>	DA <sup>5</sup>	T <sup>6</sup>	R <sup>2</sup>	DW <sup>7</sup>
Appalachia <sup>1</sup>	41.54	1,148.25**	—	-0.61*	1,537.92**	0.96	1.90
Southeast <sup>2</sup>	-436.91	956.14*	—	-.65	1,939.55**	.94	2.65
Delta States	320.12	—	4,515.50	-.47	2,377.24**	.92	2.25

— = variable is excluded from model.

Levels of statistical significance are: \*\* (1 percent) and \* (5 percent).

<sup>1</sup>Excludes West Virginia where wheat acreage was minimal, and no soybean acreage was double cropped.

<sup>2</sup>Excludes Florida where wheat acreage was minimal or zero.

<sup>3</sup>(W/C)<sub>p</sub> = Ratio of regional average wheat price (\$/lb) received by producers in t-1 to average corn price (\$/lb) received in t-1.

<sup>4</sup>(W/Ctn)<sub>p</sub> = Ratio of regional average wheat price (\$/lb) received by producers in t-1 to average upland cotton lint price (\$/lb) received in t-1.

<sup>5</sup>DA = Wheat acreage diverted from production (1,000 acres) through Federal acreage control programs in t.

<sup>6</sup>T = Dummy variable for change in technology, management, and cropping systems where 1970-80 = 0 and 1981-84 = 1.

<sup>7</sup>DW = Durbin-Watson statistic.

**Appendix table 2—Estimated associations between acres of soybeans double cropped (1,000 acres) and specified variables, 1970-84<sup>1</sup>**

Region	Intercept	WW <sup>2</sup>	(SB/GS) <sub>p</sub> <sup>3</sup>	R <sup>2</sup>	DW <sup>4</sup>
Appalachia	-959.21**	0.97**	264.66*	0.98	2.02
Southeast	-1,064.94*	.81**	588.87*	.94	1.35
Delta States	-523.11**	.76**	214.98**	.98	1.28

Levels of statistical significance are: \*\* (1 percent) and \* (5 percent).

<sup>1</sup>Soybean acreage double cropped is not available for 1972-73. Unpublished acreages for 1970-71 and 1974-77 were used in analyses. West Virginia and Florida are excluded from the Appalachian and Southeast regions, respectively.

<sup>2</sup>WW = Acres (thousands) of winter wheat planted in t.

<sup>3</sup>(SB/GS)<sub>p</sub> = Ratio of soybean and grain sorghum prices where the soybean price is the regional average (\$/lb) received by producers in t-1 and t-2 and the sorghum price is the Federal support price (Delta States) and the higher of the Federal support price or (i) the regional average producer price in t-1 (Appalachia) or (ii) the regional average producer price in t-1 and t-2 (Southeast).

<sup>4</sup>DW = Durbin-Watson statistic.